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## United States Department of Agriculture,

## BUREAU OF PLANT INDUSTRY,

## Corn Investigations,

WASHINGTON, D. C.

DIRECTIONS TO COOPERATIVE CORN BREEDERS.<sup>a</sup>

## FIRST YEAR'S WORK.

## FOUNDATION STOCK.

*Adaptation.*—Seed should be selected that has been grown under conditions of soil and climate like those in which the crop is to be planted, if such may be found.

*Mixture.*—Mixture in seed should be avoided if possible, as it will likely hinder progress. If, however, a choice must be made between a native corn that is more or less mixed, yet of long standing and productive, and a pure but radical introduction of unknown possibilities, the preference should be given to the mixed corn.

*The variety.*—With equal adaptation and purity the possibilities for improvement seem about the same for all varieties.

## SELECT SEED IN FIELD.

*Ear characters no indicator.*—So far as known the appearance of an ear, provided it is sound and well matured, indicates nothing relative to its producing power.

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<sup>a</sup>These directions are published for the convenience of cooperative corn breeders who desire to follow this method. They are necessarily complicated and should be attempted only by those having a deep interest, time, and a determination to succeed. The origination of higher yielding strains of corn is the work of specialists and requires special methods, accuracy, and good judgment. The method here outlined is one of a number of methods by which the Office of Corn Investigations is originating better yielding strains of corn. Only accurate trials for a series of years can decide which methods give the greatest, most permanent, and most profitable results.—C. P. HARTLEY, *Physiologist in Charge of Corn Investigations*.



*Select in the field.*—Seed should be taken from only such parts of the field as have an even stand and about the usual stand required. Ears should be chosen from those plants that give the heaviest yields as compared with those neighboring.

Stalks that are broken below the ear, diseased, or otherwise undesirable should be avoided.

*Select early.*—Seed should be selected as soon as mature without waiting for it to dry out.

#### TREATMENT AND STORAGE.

*Drying.*—Upon bringing seed from the field it should at once be hung or laid up, so that one ear will not rest upon another, and where there is a good circulation of air. Precaution should also be taken that nothing damages the ears.

*Storing.*—When thoroughly dry the seed should at once be placed in barrels or boxes that may be closed tightly. If there are any signs of weevils in the corn or storage receptacle at this time, a few tablespoonfuls of carbon bisulphid should be put in a dish and set upon the corn and the lids of the receptacles tightly fitted for from twenty-four to forty-eight hours. The lids should then be raised and the poisonous and explosive gas allowed to escape when no fire is present. For each bushel of corn thus stored a pound of moth balls or powdered naphthalene should be inclosed. The lids should be tightly closed at all times, except when examining the seed or working with it.

*Receptacles for storing.*—Alcohol barrels or kerosene barrels that have been flamed inside to dispose of oil are very good receptacles in which to store seed, if they have lids that can be made to fit tightly.

Heavy dry-goods boxes may be readily made into good fumigating and storage boxes by fixing a tight-fitting lid, calking the cracks, and protecting the corners and edges from mice and rats with strips of tin. A lining of heavy tar paper (such as is used for siding and roofing) may also add to the efficiency of such a box.

#### TEST A LARGE NUMBER OF SELECTIONS.

The grower's chances for finding the exceptionally valuable individuals are increased in proportion to the number of tests he makes. He should test at least 50 selections,<sup>a</sup> and 100 would be much better.

#### SEED MUST HAVE STRONG VITALITY.

Only ears having bright undamaged kernels throughout should be retained.

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<sup>a</sup> The term "selection" applies to the seed from one select plant, whether it be one ear or several.





Fig. 1.—A MODEL TEST PLAT.

St.=standard seed.  
a, b, c, etc.=substandard seed.  
St.-a=standard seed first member of hill; substandard (a), second member of hill.  
a-1=substandard seed (a) first member of hills in row No. 1; tested ear No. 1, st.  
°=standard plant.  
\*=substandard plant.  
'=plant being tested.

For the field selection of--  
 High-producing seed for testing, see top of page 2.  
 Substandard seed, see bottom of page 3.  
 Standard seed, see page 4.



## THE TEST PLAT.

The test plat has for its object the accurate comparison of the productive power of different ears of corn.

No seed is saved from this plat. Hence it may be located without reference to other corn.

It should be located on land as nearly uniform throughout as is possible to secure. The chances for uniform results may be greatly increased by unusually deep and thorough preparation of the land.

The plat should grow one row from the seed of each ear tested, and the ear and its row should be given the same number, which should be carefully recorded and preserved for future reference.

Each ear should be represented by 50 plants in as many hills.

One plant from a substandard ear (described below) should be grown in each hill with a plant from an ear to be tested.

The hills of corn should be planted by hand and in a definite manner with two plants in a hill, one a substandard and the other a plant from an ear being tested. (See model test plat, fig. 1.)

For the sake of general uniformity the first plant in the hill, that is, the plant nearest the row ends at which the work will naturally begin, should always be from the substandard seed, and the plant from seed to be tested should always be second in the hill and from 6 to 8 inches from the substandard.

## SUBSTANDARDS.

A substandard is seed taken from a single plant. It may come from one or more (in the case of prolific corn) ears. Unusual care should be taken to discard any kernels of doubtful vitality. Each substandard should be planted in ten different rows with ears to be tested. Allowance should also be made for the planting of two other rows in connection with a standard, as will be explained later. A letter (*a*, *b*, *c*, etc.) must be given each substandard and its exact location in the test plat accurately recorded.

The substandards have for their object the correction of differences in the yields of the rows due to soil variation, so that the variations in the producing power of the ears tested may be distinguished.

The substandards in connection with standards, if properly selected, may also serve as a means of determining the progress of the work. (See "Total worth of season's selections," page 7.)

## SEED USED FOR SUBSTANDARDS.

The breeder should choose his substandard and standard seed so that it will represent the unselected foundation seed or such other seed of the community as he would otherwise have to use.

This seed should be taken from stalks favored by unusual space. The occasional isolated stalk in a poor stand should be the ideal.

This method of selecting in the field will prevent the voluntary or involuntary choosing for high or low yielders and at the same time should give individuals with the maximum number of kernels.

#### STANDARDS.

In order that all the tested selections may be compared with a single standard, and hence with each other, all of the substandards should be compared with another selection called the standard. The substandards in this planting are the second members of the hills, and the standard is the first member. Two plantings of this sort should be made—preferably one on either end of the plat. In case one of these tests should be destroyed or otherwise made unreliable the key to the season's work will still not have been lost. In case both tests are good the average results should be used.

The standard seed is selected in the same way as that for the substandards, but should be sufficient (not less than 1,000 good kernels<sup>a</sup>) for planting in twice as many rows.

#### PREPARATION FOR PLANTING.

*Preparing seed.*—Each ear should be given a number. The numbers should be written on pieces of cardboard or very tough paper, about one-half inch square. A six-penny wire nail should then be forced through the label into the butt of the ear so that there will be no danger of the label becoming separated from the ear. Where there have been two or more ears saved from the same stalk they should be given the same number. In this case it is well to shell all the seed together and put it in a cloth bag.

Sufficient seed should then be taken from each selection to plant the required number of hills in its row. It should be put in a small paper bag bearing the selection number. The kernels should all be given individual inspection to be sure that none are in any way undesirable.

*Remnants.*—The remnants of the ears, after taking enough kernels for planting, should be returned to storage and carefully preserved.

*Preparation of the land.*—The land should have received all necessary preparation previous to the time of planting, and if the method of preparation does not indicate the location of the rows they should be indicated by some form of a marker or by a cord at the time of planting.

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<sup>a</sup> It is desirable, for possible future plantings, and particularly for the standard selection, to have as much seed from any one plant as it is possible to obtain; hence, in prolific corn more than one ear should be saved from a single stalk and the total quantity regarded as one ear.



A furrow may be opened for the reception of the seed, but in that case it should not be opened long enough ahead to permit it to dry out before the seed can be planted. If it is allowed to dry out, the stand may be imperfect and will be irregular in coming up.

*Distributing the bags of seed.*—Before beginning to plant it is well to distribute the bags of seed according to their number upon the proper rows.

#### PLANTING.

Two persons should drop the seed of each row, one always dropping the first member of the hill and the other always dropping the second member of the hill. Only one kernel should be dropped in the hill by each. Both kernels should be dropped at the same time and covered by a third person.

*Hand planters.*—There are small planters on the market that can be carried and operated with one hand, and where their hoppers are replaced by an open funnel-shaped tube—easily made of tin by anyone—they may be used by the droppers so as to eliminate the man with the hoe.

These planters will give a more uniform depth of planting than where a hoe is used, and there need be no danger of a dry hill as they make their own hole and cover the seed.

The soil over each kernel should be given pressure from the foot before leaving it; dry or open soil should be given more pressure than moist soil that is liable to bake.

#### HARVESTING.

*Corn must be dry.*—All rows of a test plat, and sometimes all plants in a row, may not ripen and dry out together. Particularly will the large-cobbed thick ears be slow in becoming well cured. For this reason sufficient time should be allowed for even the latest and largest ears to become air dry; otherwise extra weight due to moisture may, in calculating results, be mistaken for weight of grain, and an individual be retained for future planting that may be particularly undesirable because of its lateness or tardiness in curing.

#### RECORDS AND WEIGHINGS.

The following blank form heading indicates the notes and the manner of recording them that are essential in getting a comparison of the productive power of selections in a test.

## RECORD SHEET FOR TEST PLAT.

Grower----- Location----- Season 191--.

| Substandard letter. | Row No. | Number of perfect hills. | Total yield of ears from— |                | Yield per stalk of— |                |                      | True relative values of the selections tested. |
|---------------------|---------|--------------------------|---------------------------|----------------|---------------------|----------------|----------------------|--|
|                     |         |                          | Sub-standard.             | Tested plants. | Sub-standard.       | Tested plants. | Calculated standard. |  |
|                     |         |                          |                           |                |                     |                |                      |  |
|                     |         |                          |                           |                |                     |                |                      |  |

*Perfect hills.*—In securing comparisons only such hills as contain one productive stalk from substandard seed and one productive stalk from the seed being tested should be considered. Before husking the corn the number of these perfect hills in a row must be recorded.

*Yields from rows.*—Two men should be equipped with bags slung from their shoulders. One should gather and husk only the corn from the first plant in each hill (substandard) and the other should gather and husk only the corn from the second plant in each hill (tested plants), and the work on each hill should be done simultaneously. The corn thus gathered should be weighed separately and the weights recorded with the proper row number.

*Yield per stalk.*—The yield per stalk should then be determined for both the substandards and the tested plants.

*Calculated standard.*—The calculated standard for any row represents the yield per stalk of the standard ear had it been planted in that row.

To obtain the calculated standard, suppose, for example, that the standard had produced 0.0625 of a pound (1 ounce) per stalk more than the substandard *a*; this difference would then be added to the stalk yield of that substandard and the result would be recorded under the heading "Calculated standard." If the standard yield had been 0.0625 of a pound less than that substandard the difference would have been taken away from that substandard's yield and the result placed under the same heading.

The yield of each substandard is thus changed according as it varies from that of the standard, so that the new figures represent the standard ear in every case, and thus all of the tested selections may be compared with the same unit of production.

*True relative value of the selections tested.*—Under the last heading of the record sheet one simply fills in the differences between the tested plants and the calculated standard. Where the tested plants have yielded more than the calculated standard the difference is written with a plus sign before it, and when less, with a minus sign before it. These differences represent the true relative values of the selections



tested, and the largest differences with the plus signs before them indicate the selections that should be retained and propagated.

#### REMNANTS TO RETAIN FOR FURTHER TEST.

When the comparative values of the selections have been determined, as described, all of those remnants should be discarded whose low productiveness bars them from being classed with the 20 per cent that gave the highest yields. The high-yielding 20 per cent should still be retained for another year's test.

#### TOTAL WORTH OF SEASON'S SELECTIONS.

The total worth of the season's selections should be determined by subtracting the average stalk yield of the substandards and the standard from the average stalk yield of all the selections tested.

#### SECOND YEAR'S WORK.

##### TEST PLAT.

*Contents.*—The second year's work should consist of a test similar to that of the first year. It should contain 20 per cent of the previous year's selections and enough new selections to complete the test's required number.

*Numbering the selections.*—The new selections should be numbered simply 1, 2, 3, etc., as in the past season, and should be planted in rows of the same number. The previous test-plat selections should be given the number of the row in which they are now planted, but this number should also be accompanied by the old row number written after it. Suppose the first old selection this year is planted in row 1, and last year it was planted in row 33, its complete number this year will be 1—33. These old selections should be so arranged that one will occur in each of the first two rows of each substandard.

##### BREEDING PLAT.

*Object.*—The breeding plat is for the crossing and propagation of the high-yielding strains found in the previous year's test plat.

*Isolation.*—This plat should be so isolated that the pollen from other corn can not be blown upon it.

*Land.*—The land does not necessarily have to be uniform, but it should be of average fertility and well cultivated, so that as much seed can be grown as is possible.

*Seed used.*—The breeding plat should be planted with the remnant seed of the four highest producers of the previous year's test. In making this planting all of each remnant should be used, except that which is required for planting a row in the test plat.

*Numbering.*—In the breeding plat the selections should be designated by a Roman numeral following the previous year's test plat number. (See "Plan for crossing remnants," below.)

*Planting.*—The four selections should be planted in separate rows, but the first choice must be alternated with the rows of the other three selections so that it may shed its pollen upon all.

*Preventing inbreeding.*—The following table indicates a plan for planting and detasseling the breeding plat so as to secure cross-pollination:

*Plan for crossing remnants.*

|                      |                 |
|----------------------|-----------------|
| 21—II. Second choice | Detasseled.     |
| 33—I. First choice   | Not detasseled. |
| 42—III. Third choice | Detasseled.     |
| 33—I. First choice   | Not detasseled. |
| 7—IV. Fourth choice  | Detasseled.     |

*Rate of seeding.*—It should be observed that if the remnants are all about the same size the first-choice seed will have to be planted just half as thick as that of the other selections, because it is planted upon just twice as much row.

*Duplicating.*—In case it is not convenient to plant all seed in a single long set of rows, the set may be shortened and then duplicated. In duplicating, however, care should be taken to maintain the same relation between the different selections, and the same should all be recorded so that no mistake will be made in detasseling and harvesting. Better pollination will probably be secured by thus duplicating the set.

*Detasseling.*—When this corn begins tasseling it should be visited daily, and any tassels on the rows from the second, third, and fourth choice selections should be removed before they have begun to scatter pollen.

*Caution.*—The tassels should be pulled out carefully, so as not to break the stalks or injure the leaves more than is necessary.

#### HARVESTING TEST PLAT.

The test plat should be harvested and the results recorded in the same way as in the past season.

#### HARVESTING BREEDING PLAT.

*Selections for third year's test plat.*—Enough selections should be made from each of the four strains represented in the breeding plat to plant 10 per cent of the next season's test plat; that is, if the test plat contains 50 selections, then 5 should be made from each strain in the breeding plat, but if the plat contains 100 selections, then 10 selections should be made from each of the breeding-plat strains.



*Selections for general planting.*—All of the remaining corn from the detasseled rows that is suitable for seed should be gathered and saved for planting an improved general field the following season. No seed from the rows not detasseled should be used for this field.

If the work up to this time has been properly done there should be sufficient high-producing seed to plant at least 10 acres. Another year this can be multiplied sufficiently to furnish seed for even the largest farm or plantation.

#### MIX THE SEED FOR GENERAL PLANTING.

Before planting the seed saved from the breeding plat for general planting it should be thoroughly mixed together.

#### TO TEST BREEDING-PLAT SELECTIONS.

To test the breeding-plat selections the following season, they should be so planted in the test plat that each strain will be represented once with each substandard.

#### PLAN FOR A THIRD YEAR'S TEST PLAT.

The following table indicates a plan for planting selections with each substandard in the third year's test plat:

*Plan for planting a substandard section in the third year's test plat.*

|  | Per cent. |
|--|-----------|
| 1 (old row No.), from last year's test plat..... | 20        |
| 2 (old row No.), from last year's test plat..... |           |
| 3—I, from last year's breeding plat.....         | 40        |
| 4—II, from last year's breeding plat.....        |           |
| 5—III, from last year's breeding plat.....       |           |
| 6—IV, from last year's breeding plat.....        |           |
| 7, untried selections.....                       | 40        |
| 8, untried selections.....                       |           |
| 9, untried selections.....                       |           |
| 10, untried selections.....                      |           |

#### CONTINUOUS WORK.

##### TEST PLAT A COURT.

From year to year the test plat should be made a court in which the best corn from the unselected fields, the previous test plat, the breeding plat, and the fields of improved seed grown from ears that have already passed the test must meet yearly and stand solely upon their merits.

<sup>a</sup> The next 10 rows are planted in the same order with substandard *b*, and so on for each substandard.

## HIGH YIELDING POWER TRANSMITTED BY REMNANTS ONLY.

The quality of productiveness should be allowed to pass on into the improved field only by means of remnants of the highest yielding ears.

## PRESENT HIGH PERFORMANCE REQUIRED.

No matter what the pedigree may show, the highest record of present performance should be required of each ear before allowing its progeny to enter the improved general field, and then only after precaution is taken to prevent inbreeding as prescribed under "Breeding plat."

## ADOPTING A DIFFERENT VARIETY.

Any selections that promise better yields should be tested in the test plat, but should selections from a distinctly different variety be tested, unusual assurance from repeated trial should be obtained before it be taken up and the old strain discarded.

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